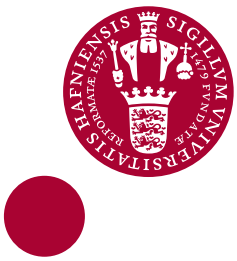

Does age modify the association between physical work demands and deterioration of self-rated general health?

Burr, Hermann; Pohrt, Anne; Rugulies, Reiner; Holtermann, Andreas; Hasselhorn, Hans Martin

Published in:
Scandinavian Journal of Work, Environment & Health

DOI:
10.5271/sjweh.3625

Publication date:
2017

Document version
Publisher's PDF, also known as Version of record

Original article

Scand J Work Environ Health 2017;43(3):241-249

doi:10.5271/sjweh.3625

Does age modify the association between physical work demands and deterioration of self-rated general health?

by Burr H, Pohrt A, Rugulies R, Holtermann A, Hasselhorn HM

The study findings suggest that physical work demands, in particular demanding body postures, have a stronger impact on health among older employees than among younger employees.

Affiliation: Federal Institute for Occupational Safety and Health (BAuA), Nöldnerstraße 40–42, D–10317 Berlin, Germany. burr.hermann@baua.bund.de

Refers to the following text of the Journal: 2003;29(4):0

Key terms: age; ageing; association; demanding body posture; DWECS; interaction; older worker; physical work demand; self-rated health; strenuous work

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/28251240

Additional material

Please note that there is additional material available belonging to this article on the *Scandinavian Journal of Work, Environment & Health* -website.

Original article

Scand J Work Environ Health. 2017;43(3):241–249. doi:10.5271/sjweh.3625

Does age modify the association between physical work demands and deterioration of self-rated general health?

by Hermann Burr, PhD,[1] Anne Pohrt, MSc,[1] Reiner Rugulies, PhD,[2, 3, 4] Andreas Holtermann, PhD,[2, 5] Hans Martin Hasselhorn, MD [6]

Burr H, Pohrt A, Rugulies R, Holtermann A, Hasselhorn HM. Does age modify the association between physical work demands and deterioration of self-rated general health? *Scand J Work Environ Health*. 2017;43(3):241–249. doi:10.5271/sjweh.3625

Objective Due to the growing proportion of older employees in the work force in several countries, the importance of age in the association between work and health is becoming increasingly relevant. Few studies have investigated whether age modifies the association of physical work demands with health. We hypothesized that the association of demanding body postures with deteriorated self-rated health (SRH) is stronger among older employees than among younger employees.

Method We analyzed three 5-year cohorts in the Danish Work Environment Cohort Study comprising 8318 observations from 5204 employees (follow-up participation rate 83%) with good baseline SRH. Physical work demands were assessed as demanding body postures. Age was divided into tertiles; young (18–32 years), middle–aged (33–43 years) and old (44–59 among men and 44–54 years among women). Poor SRH ("fairly good", "poor", and "very poor") was measured with a single item. Log binomial regressions were stratified by gender. Effect modification (ie, interaction) was defined as deviation from additivity and examined by calculating the relative excess risk due to interaction (RERI). The reference group was employees aged 18–32 years with low physical exposure.

Results When predicting deterioration of SRH, an interaction between demanding body postures and age was found among men [RERI: 0.75, 95% confidence interval (95% CI) 0.16–1.34, regarding the age group 44–59 years] and among women (RERI: 0.84, 95% CI 0.19–1.34, for the age group 33–43 years; and 1.17, 95% CI 0.42–1.93, for the age group 44–54 years).

Conclusion The study findings suggest that demanding body postures have a stronger impact on health among older compared to younger employees.

Key terms ageing; demanding body posture; DWECS; interaction; older worker; strenuous work.

Exposure to high physical work demands, ie, demanding body postures, repetitive movements, and heavy lifting, has been found to increase the risk for subsequent development of poor self-rated health (SRH) (1–3). SRH is a powerful global indicator of health as it strongly predicts morbidity and mortality (4–6). However, little is known epidemiologically about the importance of age for the association between physical work demands and SRH, even in the case that some regulatory limits of physical work demands take age's modifying role into account (7).

Identifying the role of age in the association between work and health is becoming increasingly relevant due to the growing proportion of older employees in the workforce in many industrialized countries. This development is caused by the ageing of adult populations due to low birth rates, increasing life expectancy, and new policies that increase the statutory retirement age in several countries (8).

When analyzing the relation between working conditions and health, age is conventionally treated as a confounder (9), implying that analyses on working

1 Federal Institute for Occupational Safety and Health (BAuA), Berlin, Germany.
2 National Research Centre for the Working Environment, Copenhagen, Denmark.
3 Department of Public Health, University of Copenhagen, Copenhagen, Denmark.
4 Department of Psychology, University of Copenhagen, Copenhagen, Denmark.
5 Institute of Sport Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark.
6 Department of Occupational Science, University of Wuppertal, Wuppertal, Germany.

Correspondence to: Hermann Burr, Federal Institute for Occupational Safety and Health (BAuA), Nöldnerstraße 40–42, D–10317 Berlin, Germany. [E–mail: burr.hermann@baua.bund.de].

conditions and health are usually adjusted for age. However, there are substantial reasons to consider age as an effect modifier instead of a confounder. Older workers can be expected to differ physiologically from younger workers in at least two respects. First, physiological fitness and health parameters are subject to a decline with chronological age (10) and consequently older workers have a lower physical capacity than younger workers (11). Second, older workers may have accumulated more adverse occupational exposure merely due to total duration in a given occupation (years at work) as compared to younger workers, thus contributing to a higher degree of cumulative physical "wear and tear". These mechanisms are expected to increase vulnerability among older workers. We therefore expect age to modify the impact of physical work demands on SRH, ie, that the impact of physical demands on SRH is stronger among older than younger workers.

If physical work demands have a stronger impact on the health of older workers than that of younger workers, this would have consequences for research and prevention. In epidemiological research, for instance, adjusting for age when assessing outcomes related to physical work demands would be inappropriate if age is an effect modifier. In prevention, much more attention should be given to the age of the worker with respect to performing physical work with high demands.

To our knowledge, only two studies have investigated whether the association of physical work demands with health is modified by age. A longitudinal study by Parkes et al (2) found no interaction between age and physical work demands as risk factors for worsened SRH, but this study was limited by very low statistical power with only 314 participants. Aittomäki et al (12) found that the association of physical work demands with poor health was stronger among older than younger employees (12); however, the cross–sectional study design did not permit causal inference. In addition, Aittomäki et al found that the interaction between age and physical work demands was stronger among women than men. Maybe this was explained by a gender dependent exposure pattern; older men ceased to be exposed to a higher degree than older women.

In this article, we examine the association of physical work demands and declining SRH in a large-scale prospective study, stratified by gender, thus overcoming the limitations of the two earlier studies. We hypothesize that the association of physical work demands with declining SRH will be stronger among older than younger employees.

Method

Population

We extracted three cohorts from the Danish Work Environment Cohort Study (DWECS) and followed each for five years. DWECS was an open cohort study investigating work and health among the working population in Denmark by means of repeated questionnaire assessments every five years from 1990 until 2010 (13). In each new wave, young people and immigrants were included in the study (13). The cohorts in the 1990 to the 2000 waves served as baseline and were then followed-up in the subsequent waves from 1995 to 2005.

A participant in the present study could have taken part in up to three cohorts, given that he or she was an employee and aged 18–59 years (men) or aged 18–54 years (women) (figure 1); gender-specific upper-age cut points were chosen to avoid strong selection due to withdrawal from the labor market near retirement (8).

The average response at baseline was 83% (table 1a). The average response among employees in the baseline participating in the follow-ups was also 83%. Participation differed only substantially in the last baseline where men had a lower participation than women (4 percentage points difference) (table 1a). Attrition during the five year follow–up for the baseline participants in question for the present paper, namely employees, differed substantially regarding gender, age and demanding body postures in the last cohort (table 1b). Regarding social class attrition, contrasts grew from 4 percentage points in the 1990–1995 cohort to 8 percentage points in the 2000–2005 cohort (table 1b). A total of 2430 responses in the 2005 follow–up were left out as they were based on paper or internet questionnaires with a different response pattern (if they were kept for the analyses, mode of data collection interacted with the independent variables as predictors for deterioration of SRH (data not shown). Those left out differed only substantially regarding age – younger workers were overrepresented – data not shown) (13). Of the remaining 9 556 observations, 216 had missing information on at least one variable. A total of 1 022 observations had poor SRH at baseline and were excluded from the analyses as we were only interested in worsening of health among those with good health at baseline. The analyses in the present paper were thus based on the remaining 8318 observations from 5204 employees (2539 employees took part in only one cohort, whereas 1 347 took part in all three, mean observations per participant was 1.6). Of the observations, 49% were from women. The mean age was 36.8 years for men and 36.3 years for women.

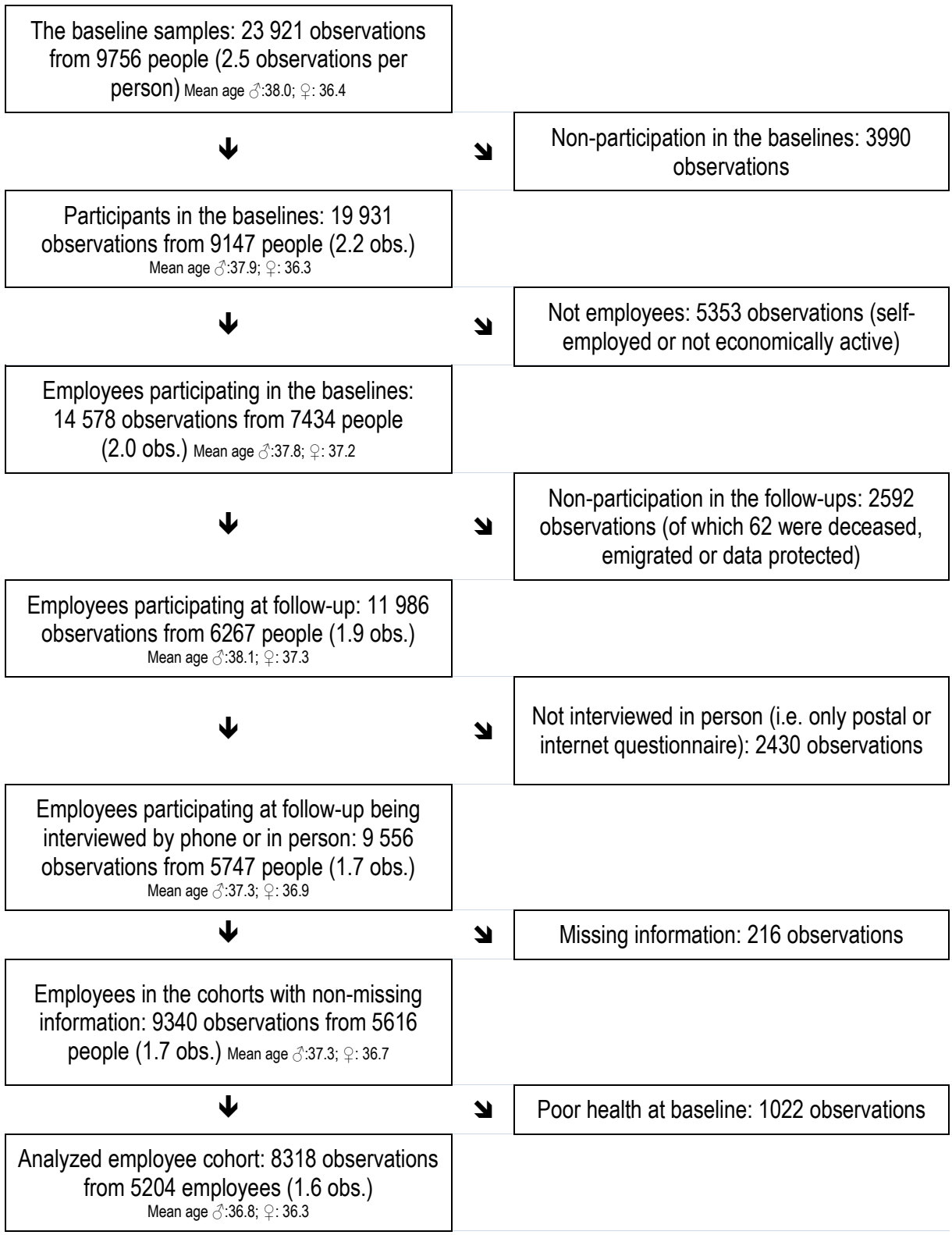

Figure 1. Flow diagram of participation in the 1990, 1995 and 2000 baselines and the 1990–1995, 1995–2000 and 2000–2005 cohorts. Average participation rate for the baseline was 83% (19 931/23 921, see table 1a). Average participation for the follow-up was also 83% (11 986/14 504, see table 1b).

Table 1a. Participation among people[a] drawn in the baseline samples 1990, 1995 and 2000 by gender and age.

	Gender		Age (years)			Total	
	Men	Women	18–32	33–43	≥44		
	%	%	%	%	%	%	N
1990	90	92	91	92	90	91	7805
1995	81	83	81	83	82	82	8063
2000	75	80	76	78	78	77	8053

[a] Men aged 18–59 years; women aged 18–54 years. Regarding the gender-specific upper-age cut points, see population subsection in the Methods section.

Table 1b. Attrition in the follow–ups 1995, 2000 and 2005 among employees[a] in the baselines 1990, 1995 and 2000 by gender, age, demanding body posture and social class at baseline.

	Gender		Age (years)			Demanding body posture		Social class		Total	
	Men	Women	18–32	33–43	≥44	Low	High	Low[b]	High[c]		
	%	%	%	%	%	%	%	%	%	%	N
1990	86	87	87	87	87	88	86	85	89	87	5130
1995	85	86	85	87	84	86	84	83	88	85	4702
2000	73	78	80	77	68	77	71	71	79	75	4672

[a] Men aged 18–59 years; women aged 18–54 years. Regarding the gender-specific upper-age cut points, see population subsection in the Methods section.

[b] Routine/low technology/low sales and service.

[c] Intermediate occupation/professional, supervisors, high technology, high sales and service.

Variables

Outcome. SRH was measured by the single question "How do you rate your health in general?" with the response categories "very good", "good", "fairly good", "poor" and "very poor". In accordance with Manor et al (14), we collapsed "very good" and "good" into "good health" and the three other responses into "poor health".

Predictors. Information on age and gender was derived from register data. Age was divided into tertiles; young (18–32 years), middle–aged (33–43 years) and old (44–59 for men and 44–54 for women) (Regarding the reason for gender-specific upper-age cut points, see the population subsection above). All other variables were based on self-reports.

Demanding body postures was a dichotomous variable based on a 2-item scale (15): "Does your work involve sitting?" and "Does your work involve squatting or kneeling?" with the responses "Almost all the time" (=0 for the first question so as to measure walking and standing work posture and =4 for the second question), "Approximately ¾ of the time"=1 and 3, "Approximately ½ of the time"=2 and 2, "Approximately ¼ of the time"=3 and 1, "Rarely/very little"=3.75 and 0.25, "Never"=4 and 0. The scale had a Cronbach's α of 0.48; the two items had a Pearson correlation of 0.36. The scale value was computed as mean of item values, then dichotomized at the highest quartile by the value of 2, indicating a mean exposure of ½ of the working hours or more. For a sensitivity analysis, where a linear regression was carried out, the scale version of this variable was used.

Covariates. A job control scale was constructed on the basis of the following three questions which were available in all waves of the study (16): "Do you participate in planning your own work (eg, what to do, how to do it, or who to work with)?", "Does your work require that you repeat the same work tasks many times per hour?", and "Is your work varied?", where the response options were coded from 0–4. Values for the response options for the last question were reversed. Cronbach's α for the three rounds was 0.63, and the inter–item correlation varied between 0.29–0.41.

Social class was measured by means of the European Socioeconomic Classification (ESeC) (17), where the category "lower services/sales/clerical occupations" was moved into category "lower salaried".

Statistical analysis

In order to inspect possible collinearity, correlation analyses (Kendall Tau B) of the independent variables were carried out. Demanding body postures correlated with job control at -0.25 among men and at -0.14 among women. Demanding body postures correlated with social class at 0.36 among men and at 0.35 among women. Job control and social class correlated with -0.39 among men and -0.32 among women. Thus, no indication of collinearity was found.

Regression analyses were carried out stratified by gender. Prevalence ratios (PR) for prevalence of demanding body postures (cross sectional analyses) and risk ratios (RR) for deterioration of SRH (analyses of change over time) and their confidence intervals (95% CI) were calculated using the log-binomial method (18) assuming correlation between observations belonging to the same person. The log-binomial method [sometimes also called the multiplicative method (19)] can be used to estimate the ratio between risks – or prevalences – among exposed and unexposed. We used interaction analyses using RR to assess age modification, see below (20, 21).

First, we examined in a regression analysis if demanding body postures (categorical) predicted the 5-year deterioration of self–rated health (ie, new cases of poor self–rated health among people who at baseline had good self–rated health) with the covariates age group (categorical), job control (linear) and social class (linear). In sensitivity analyses (descriptive and in a

regression using the log–binomial method), we assessed if the two items used to construct the demanding body posture measure (sitting, reversed and kneeling/squatting) had the same prediction of the outcome.

Second, in a regression analysis to investigate whether age group (middle or older versus younger) modified the association of demanding body postures with declining SRH, we performed interaction analyses. In general, interaction may be defined as either departure from additivity or from multiplicativity (22). We chose to analyze departure from additivity because this is relevant from a public health perspective and it helps to identify which groups might benefit from certain interventions (22). Interaction effects were thus analyzed by calculating the relative excess risk due to interaction (RERI) with the formula set out in equation 1 below (22).

RERI can be understood as the amount of extra risk due to the combined effect of exposure to demanding body postures and age as compared to the base risk. We used the Delta method to calculate 95% CI (20, 21). More specifically, this calculation requests the estimation of RR (odds ratios can be used only as a substitute) for all combinations of the two variables in question (20, 21); as the log binomial method can estimate RR directly, we chose this regression method.

When RERI≠0, an additive interaction is present. RERI can vary from negative to positive infinity. RERI <0 indicates subadditivity, and RERI >0 indicates super additivity.

In two additional sensitivity analyses, we (i) included those with poor SRH at baseline in the regressions, controlling for SRH at baseline. Since few people reported poor SRH, it became necessary to apply logistic regression here, as the log binomial method does not work with few or no observations in combinations of the independent variables. We (ii) analyzed demanding body postures and age and the product of these two variables as linear variables. In the linear regression, deviations from the product of body postures and age are deviations from additivity and as such it is the linear regression equivalent to the assessment of RERI when predicting discrete outcomes. The scale versions of the variables body postures and age were centered to the mean and transformed so that their standard deviations (SD)=1. These transformations were required in order to assess interaction.

Analyses were carried out in SPSS version 20 and 21 (GENLIN, IBM Corp, Armonk, NY, USA).

Results

Across all rounds in the study, demanding body postures were less prevalent among older male employees than their younger counterparts: 44% among men aged 18–32 years, 30% among men 33–43 years, and 24% among men aged 44–59 years. Among female employees, the prevalence of demanding body postures was about 30% in all age groups (33% among women aged 18–32 years; 28% among the 33–43-year-olds, and 31% among the 44–54-year-olds). This pattern was the same in each round of the study (table 2).

Table 3 presents the association of baseline age and physical exposure with the deterioration of SRH at follow–up. Higher age predicted the deterioration of SRH among both men and women. Physically demanding body postures predicted poor SRH in women, there was an elevated, but not significant risk among men. In a sensitivity analysis, we found that both items used to construct the measure of physically demanding body postures (sitting less than ½ of working hours; squatting/kneeling at least ½ of working hours) had risks of the same level for poor SRH among men and women as for the measure physically demanding body postures (supplementary table A, www.sjweh.fi/index.php?page=data-repository).

Table 4 shows the analyses for the possible interaction of age with physical exposure on the risk of incident poor SRH. Regarding demanding body postures, a statistically significant interaction with age was observed when comparing older with younger men, as we could identify an RERI of 0.75 (95% CI 0.16–1.34, see table 4, row 6), indicating super additivity (ie, a positive interaction). This means that both exposures together had an effect that was stronger than the sum of the observed single effects. The additional risk due to this positive interaction was 0.75 times the base risk without the exposures older age and demanding body postures. Among middle aged men an insignificant positive RERI of 0.51 (-0.01–1.06) was found. Also, an interaction of demanding body postures with age was observed when separately comparing middle-aged and older women with the younger group. In both cases, a positive RERI was found (0.84, 95% CI 0.19–1.49 and 1.17, 95% CI 0.42–1.93; see third last and last rows in table 4).

$$RERI = (RR_{exposed\ \&\ higher\ age} - 1) - (RR_{exposed\ \&\ lower\ age} - 1) - (RR_{not\ exposed\ \&\ higher\ age} - 1) \quad \textbf{Equation 1}$$

Table 2. Prevalence of demanding body postures by gender and age: 8318 observations from 5204 employees[a] without poor self–rated health (SRH) at the baselines 1990 to 2000. **Bold denotes significant prevalence ratios[b] (PR).** [95% CI=95% confidence interval.]

	1990				1995				2000			
	N	%	PR	95% CI	N	%	PR	95% CI	N	%	PR	95% CI
Men (years)												
18–32.	827	49	1		727	39	1		168	42	1	
33–43	637	33	**0.67**	**0.59–0.77**	542	29	**0.75**	**0.64–0.88**	161	20	**0.49**	**0.35–0.70**
44–59	579	26	**0.54**	**0.46–0.63**	593	21	**0.55**	**0.46–0.66**	151	30	**0.73**	**0.54–0.99**
Total	2043	37			1862	30			480	31		
Women (years)												
18–32	728	36	1		602	29	1		144	31	1	
33–43	633	32	0.88	0.76–1.02	556	25	0.87	0.72–1.05	173	21	0.68	0.47–1.00
44–54	444	39	1.07	0.92–1.25	490	24	0.84	0.69–1.03	163	29	0.92	0.66–1.30
Total	1805	35			1648	26			480	27		

[a] Men aged 18–59 years; women aged 18–54 years. Regarding the gender-specific upper-age cut points, see population subsection in the Methods section.
[b] A PR can be interpreted as the fraction of the prevalence in the age group of the prevalence in the comparison age group (younger employees).

Table 3. Five-year deterioration of self-rated health (SRH): 8318 observations from 5204 Danish employees [a] without poor health at the baselines 1990–2000 by demanding body postures, stratified by gender. **Bold denotes significant risk ratios (RR).** Baseline data from 1990, 1995, 2000 and follow–up data from 1995, 2000, 2005. Controlled for repeated measurements. [95% CI=95% confidence interval.]

	N	New cases poor SRH at follow-up (observed %)	RR[b]	95% CI	RR (adjusted for job control [c])	95% CI	RR (adjusted for social class [d])	95% CI	RR (fully adjusted)	95% CI
Men										
Age group, years										
18–32	1722	8	1		1		1		1	
33–43	1340	12	**1.60**	**1.29–2.00**	**1.67**	**1.34–2.08**	**1.69**	**1.35–2.10**	**1.71**	**1.37–2.13**
44–59	1323	14	**1.93**	**1.55–2.40**	**2.05**	**1.65–2.55**	**2.06**	**1.65–2.56**	**2.11**	**1.69–2.62**
Demanding body postures										
No	2907	10	1		1		1		1	
Yes	1478	12	**1.36**	**1.14–1.63**	**1.21**	**1.01–1.47**	1.10	0.90–1.33	1.08	0.89–1.31
Women										
Age group, years										
18–32	1474	7	1		1		1		1	
33–43	1362	11	**1.57**	**1.24–2.00**	**1.66**	**1.31–2.12**	**1.64**	**1.39–2.09**	**1.68**	**1.32–2.13**
44–54	1097	15	**2.24**	**1.78–2.82**	**2.32**	**1.84–2.93**	**2.26**	**1.80–2.85**	**2.30**	**1.83–2.90**
Demanding body postures										
No	2732	9	1		1		1		1	
Yes	1201	15	**1.71**	**1.43–2.05**	**1.60**	**1.34–1.92**	**1.43**	**1.18–1.74**	**1.44**	**1.18–1.75**

[a] Men aged 18–59 years; women aged 18–54 years. Regarding the gender-specific upper-age cut points, see population subsection in the Methods section.
[b] Age controlled for demanding body postures. Demanding body postures controlled for age.
[c] But not for social class.
[d] But not for job control.

In two sensitivity analyses, we included those with poor health at baseline and analyzed the exposures and age as linear variables. Both sensitivity analyses yielded results similar to the main analyses (supplementary tables B and C, www.sjweh.fi/index.php?page=data-repository).

Discussion

Our analyses indicate that a high level of demanding body postures is more harmful for the health of older than younger employees.

These findings may indicate a higher vulnerability among older employees. This vulnerability could be due to (i) the – on average – longer lifetime occupational exposure of older employees (9) or (ii) a lower mean physical capacity of older employees leading to a higher relative workload while performing the same manual work as compared to younger employees (10, 11).

The pattern of a stronger modification between physical work demands and age was clearer among women than men. Of course one should note that the older age groups of the two genders are not fully comparable as older men comprise the 44–59-year-old group, whereas older women only comprise the 44–54-year-olds. It

Table 4. Five-year deterioration of self-rated health (SRH): 8318 observations from 5204 Danish employees[a] without poor health at baseline (1990–2000) by combinations of demanding body postures and age group. **Bold numbers denote significant risk ratios (RR)**. Baseline data: 1990, 1995, 2000 and follow-up data: 1995, 2000, 2005. Controlled for repeated measurements. [95% CI=95% confidence interval, RERI=relative excess risk due to interaction.]

Demanding body postures	Age (years)	N	New cases poor SRH at follow-up (observed %)	RR[b]	95% CI	RERI[c]	95% CI
Men							
No	18–32	967	8	1			
Yes	18–32	755	7	0.75	0.54–1.05		
No	33–43	941	10	**1.39**	**1.05–1.84**		
Yes	33–43	399	15	**1.65**	**1.20–1.28**	0.51	-0.01–1.06
No	44–59	999	12	**1.66**	**1.26–1.94**		
Yes	44–59	324	20	**2.17**	**1.60–2.94**	**0.75**	**0.16–1.34**
Women							
No	18–32	991	7	1			
Yes	18–32	483	8	0.98	0.66–1.46		
No	33–43	983	9	**1.37**	**1.00–1.86**		
Yes	33–43	379	16	**2.19**	**1.58–3.04**	**0.84**	**0.19–1.49**
No	44–54	758	12	**1.85**	**1.37–2.51**		
Yes	44–54	339	24	**3.01**	**2.21–4.09**	**1.17**	**0.42–1.93**

[a] Men aged 18–59 years; women aged 18–54 years. Regarding the gender-specific upper-age cut points, see population subsection in the Methods section.

[b] Adjusted for baseline job control (influence and possibilities for development) and social class.

[c] RERI=[RR (poor physical work demands & higher age)–1] – [RR (poor physical work demands & lower age)–1] – [RR (good physical work demands & higher age)–1].

might be that a lower physical capacity among women could explain this apparent difference (11). Also different selection processes in the two genders might offer an explanation (12). We have found that middle-aged and older women remain exposed to physical work demands to a stronger degree than middle aged and older men (table 2). Among women, physical work demands occur predominantly in healthcare, kindergarten and social worker jobs, whereas physical work demands in male jobs occur in industrial and other manual technical occupations (23). An explanation for the different age–related exposure pattern in the two genders might be that female occupations offer fewer advancement opportunities away from physical exposure than male occupations do. (We are however not aware of analyses investigating such suggested exposure related occupational histories.)

The association between demanding body postures and SRH was confounded by job control and social class (table 2). In fact, by adjusting for job control and social class, the effect of demanding body postures decreased by more than ¾ among men and almost ½ among women. It might be that a further control for other social aspects would decrease the effect of physical work demands even more.

In this paper, we have assessed effect modification by assessing deviations from additive effects of physical work demands and age. We find this approach meaningful, as we would expect – if no modification would take place – that physical work demands should have the same effect among older and younger workers (22). Alternatively, if one would only assess deviations from multiplicativity, then – by definition – one would have to assume that the effects of physical work demands should differ in age groups when no deviation from an interaction was present. To us, a multiplicative approach makes, therefore, less sense (22).

Strengths and weaknesses

A major strength of this study is that DWECS provided 8318 5-year windows for the analyses (1.6 per participant) as high statistical power is required for determining effect modification (24). DWECS also contained information on job control and social class in all three rounds, which allowed us to adjust for these important potential confounders that are known to correlate with physically demanding work (1). More specifically, when not considering job control and social class as possible confounders, one would run the risk of overestimating the role of physical work demands on SRH (1). Importantly, DWECS is a longitudinal study allowing for analyses of changes in SRH. Moreover, people in the cohort who left work were followed up. As poor health can lead to an exit from the labor market (25), a restriction to only those employees remaining in work at follow-up would lead to a potentially serious underestimation of associations between physical work demands and SRH.

The strengths of this study need to be balanced against its weaknesses. First, self-assessments of physical work demands may be biased by poor health (26). We have – as a side effect – minimized this problem by only including participants with good health at baseline (this inclusion criteria was set up as we only wanted to look at deterioration of health in the present study). Second by categorizing demanding body postures and age for the interaction analyses, power was lost in the assessment of RERI (20). This categorizational problem is somewhat reduced as most people in the cohort had a very low level of physical work demands (75% had a level <2 in scales ranging from 0–4). However, we have no knowledge from other studies as to whether our cut-off point did in fact grasp the point to which impaired health would occur, and we have refrained from a data driven approach to determine the cut-off point. Third, we only adjusted for one psychosocial

dimension, namely job control. It would have been beneficial to have had access to more psychosocial measures, which were present in all rounds of DWECS. Fourth, this study is observational and thus, as always in such studies, selection occurs. Here we would like to mention that we only included people at baseline not yet undergoing the strong – partly health-related – selection processes arising at the end of the labor market career (males <60 and women <55 years) (8). Also, there is a relatively high participation at the baselines and a relatively low attrition during follow-up. Fifth, it could be criticized that we did multiple significance tests as we have looked at eight interactions between physical work demands and age (two genders×one exposure×two age groups=4) with a significance level of 0.05. That means that our study by chance should generate 0.2 significant findings of deviating RERI; in fact we found 3 – all pointing in the same expected direction. It is therefore unlikely that our results are due to chance.

Comparison with other studies

To our knowledge, a modification due to age in the association between physical work demands and health has only been investigated in two studies. One study of 314 British off-shore workers who were followed up five years later did not find interactions between physical activity at work and age as predictors of SRH (2). However this study had very low statistical power.

In another – and much larger – study of 5802 40–60-year-old employees of the City of Helsinki, analyses similar to our study were performed, albeit on the basis of cross-sectional data (12). The outcome was "role limitations due to physical health problem" (an SF–36 measure), and the risk factor "physically demanding work" also comprised heavy lifting. First, the study found that – among women but not men – age interacted with "physically demanding work". This apparently stronger interaction among women resembles our findings (table 3). Second, the study found that "physically demanding work" occurred almost as often among older as younger women, but much less often among older compared to younger men. A similar gender pattern was likewise found in the present study (table 2).

Concluding remarks

The findings in the present study suggest that physical work demands have a stronger impact on the health of older compared to younger employees. Thus, for the association of physical work demands with health, age seems rather to be an effect modifier than a confounder. It also seems that this modification effect is stronger among women, which could be explained by our finding that older women stay exposed to physical work demands whereas older men cease to be exposed. If these findings can be substantiated by further research, this would have important consequences for both research (eg, stratifying instead of adjusting for age) and practice (eg, more attention to the age and life time exposure of employees when developing workplace modifications).

Acknowledgements

The authors are grateful for the valuable comments by the anonymous reviewers and to earlier versions of the manuscript by Dr. Martin Schütte and Dr. Maren Formazin from the Federal Institute for Occupational Safety and Health. The 1990 round of the Danish Work Environment Cohort Study was partly funded by the Danish Health Insurance Fund and by the Danish Work Environment Fund (grant 1989–04). The 1995 round was funded by the Danish governmental research program concerning repetitive monotonous work. The 2000 round was funded by the Danish Working Environment Authority and the Ministry of Employment. The 2005 round was funded by the Ministry of Employment as a part of a surveillance program on occupational health.

The authors declare no conflict of interest. The DWECS has been notified to and registered by the Danish Data Protection Agency (Datatilsynet; see www.datatilsynet.dk/english for details). Questionnaire based studies do not need approval from the Danish National Committee on Biomedical Research Ethics (Den Centrale Videnskabetiske komité; see www.dnvk.dk/English/guidelinesaboutnotification.aspx for details).

References

1. Borg V, Kristensen TS, Burr H. Work environment and changes in self–rated health: A five year follow–up study. Stress Medicine. 2000;16(1):37–47. https://doi.org/10.1002/(SICI)1099–1700(200001)16:1<37::AID–SMI830>3.0.CO;2–O.

2. Parkes KR. Physical activity and self–rated health: interactive effects of activity in work and leisure domains. Br J Health Psychol. 2006;11(Pt 3):533–50. https://doi.org/10.1348/135910705X59951.

3. Niedhammer I, Chea M. Psychosocial factors at work and self reported health: comparative results of cross sectional and prospective analyses of the French GAZEL cohort. Occup Environ Med. 2003;60(7):6. https://doi.org/10.1136/oem.60.7.509.

4. Singh–Manoux A, Martikainen P, Ferrie J, Zins M, Marmot M, Goldberg M. What does self rated health measure? Results

from the British Whitehall II and French Gazel cohort studies. J Epidemiol Community Health. 2006;60(4):364–72. https://doi.org/10.1136/jech.2005.039883.

5. Bjorner JB, Kristensen TS, Orth–Gomér K, Tibblin G, Sullivan M, Westerholm P. Self–rated health : A useful concept in research, prevention and clinical medicine. Stockholm: Swedish Council for Planning Coordination of Research F. R. N.; 1996.

6. Idler E, S. K. Health perceptions and survival: do global evaluations of health status really predict mortality? J Gerontol. 1991;46:55–65. https://doi.org/10.1093/geronj/46.2.S55.

7. Hecktor K. ErgonLoad: Ein rechnerunterstütztes Analysesystem zur Simulation von Arbeitsabläufen unter der Berücksichtigung von ergonomischen und physiologischen Kennwerten einschließlich der Prognose von Erholzeiten zugl. Dissertation [ErgonLoad : A computer–based analysis system for the simulation of work processes, taking ergonomic and physiological characteristics into account of including also the prognosis of recovery times. Thesis]. Düsseldorf: VDI–Verlag; 2001.

8. Ebbinghaus B, Hofäcker D. Reversing Early Retirement in Advanced Welfare Economies A Paradigm Shift to Overcome Push and Pull Factors. Comparative Population Studies – Zeitschrift für Bevölkerungswissenschaft. 2013;38(4):807–40.

9. Lange AHd, Taris TW, Jansen PGW, Smulders P, Houtman I, M. K. Age as factor in the relation between work and mental health: Results of the longitudinal TAS survey. In: McIntyre S, Houdmont J, editors. Occupational health psychology : European perspectives on research, education and practice. 1. Maia: ISMAI Publications; 2006.

10. Sluiter JK. High–demand jobs: age–related diversity in work ability? Appl Ergon. 2006;37(4):429–40. https://doi.org/10.1016/j.apergo.2006.04.007.

11. Faber A, Hansen K, Christensen H. Muscle strength and aerobic capacity in a representative sample of employees with and without repetitive monotonous work. Int Arch Occup Environ Health. 2006;79(1):33–41. https://doi.org/10.1007/s00420–005–0025–z.

12. Aittomaki A, Lahelma E, Roos E, Leino–Arjas P, Martikainen P. Gender differences in the association of age with physical workload and functioning. Occup Environ Med. 2005;62(2):95–100. https://doi.org/10.1136/oem.2004.014035.

13. Feveile H, Olsen O, Hogh A. A randomized trial of mailed questionnaires versus telephone interviews: response patterns in a survey. BMC Med Res Methodol. 2007;7:27. https://doi.org/10.1186/1471–2288–7–27.

14. Manor O, Matthews S, Power C. Dichotomous or categorical response? Analysing self–rated health and lifetime social class. Int J Epidemiol. 2000;29(1):149–57. https://doi.org/10.1093/ije/29.1.149.

15. Wikman A, Ørhede E. Pilotprojekterne i Danmark og Sverige. [The pilot projects Denmark and Sweden] Stockholm and Copenhagen: Statistics Sweden and The National Institute of Occuptional Health; 1988.

16. Burr H, Bjorner J, Kristensen T, Tüchsen F, Bach E. Trends the Danish work environment and their associations with labor–force changes. Scan J Work Environ Health. 2003;29:270–9. https://doi.org/10.5271/sjweh.731.

17. Wirth H, Gresch C, Müller W, Pollak R, Weiss F. Validating the ESeC–scheme as operationalization of social class the case of Germany. Mannheim: Mannheimer Zentrum für Europ. Sozialforschung; 2009.

18. Skov T, Deddens J, Petersen M, Endahl L. Prevalence proportion ratios: estimation and hypothesis testing. Int J Epidemiol. 1998;27(1):91–5. https://doi.org/10.1093/ije/27.1.91.

19. Breslow NE, Day NE. Statistical Methods in Cancer Research Volume II – The Design and Analysis of Cohort Studies: IARC Publications; 1987.

20. Andersson T, Alfredsson L, Källberg H, Zdravkovic S, Ahlbom A. Calculating measures of biological interaction. European Journal of Epidemiology. 2005;20(7):575–9. https://doi.org/10.1007/s10654–005–7835–x.

21. Andersson T, Alfredsson L, Källberg H, Zdravkovic S, Ahlbom A. Excel sheet to calculate measures of biological interaction. Available from: http://www.epinet.se/Epidemiologicaltools.htm2005.[cited 2014 December 9].

22. Rothman K. Epidemiology. An introduction. New York: Oxford University Press; 2002.

23. Borg V, Burr H. Danske lønmodtageres arbejdsmiljø og helbred 1990–95. [Working conditions and health among Danish employees 1990–1995]. Copenhagen: Arbejdsmiljøinstituttet; 1997. p. 370.

24. Lubin J, JM. S, C. W. Design issues in epidemiologic studies of indoor exposure to Rn and risk of lung cancer. Health Phys. 1990;59(6):807–17. https://doi.org/10.1097/00004032–199012000–00004.

25. van den Berg T, Schuring M, Avendano M, Mackenbach J, Burdorf A. The impact of ill health on exit from paid employment in Europe among older workers. Occup Environ Med. 2010;67(12):84—52. https://doi.org/10.1136/oem.2009.051730.

26. Mikkelsen S, Vilstrup I, Lassen CF, Kryger AI, Thomsen JF, Andersen JH. Validity of questionnaire self–reports on computer, mouse and keyboard usage during a four–week period. Occup Environ Med. 2007;64(8):541–7. https://doi.org/10.1136/oem.2005.026351.

Received for publication: 16 September 2016